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EFFECTS OF CHEMICAL ADDITIVES ON THE PRESSURE DROP IN THE PIPES

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ABSTRACT

In this work; effect of carboxyl methyl cellulose (CMC) surfactant material on the pressure drop in pipes has been studied by using F-18 pressure drop through pipes measurement rig supplied by Armfeild has been used. Different amounts of the CMC material has been added to the solution, and the pressure drop at each amount has been recorded. This work was conductor in laminar flow vane it was found that a noticeable reduction in pressure drop reduction may be obtained by adding these amounts. Variables in this work were volumetric flow rate and percent of the added CMC in the solution.

KEYWORDS: Head Loss, Pressure Drop, Dray Reduction, CMC Surfactant

INTRODUCTION

Pressure drop in pipes can play an important rule in power saving in transporting fluids through pipes. So the study of pressure drop reduction (drag reduction) became a significant. For example in oil pipelines; drag reduction and hence pressure drop reduction can increase the flow rate for a given pipe's diameter or to save pumping energy or both. Pressure drop can occurs as a result of a mechanical force that resists the movement of the fluid through the pipe [1]. That the frictional resistance of fluids can be reduced by the addition of small quantities of certain compounds [2]. The discovery made by these two authors has stimulated a large number of investigations, most of which have been performed using high molecular polymers as additives [3]. In contrast, drag reduction by surfactants has so far been much less thoroughly investigated. So, surfactant additives can be used to reduce the pressure drop in a noticeable amount. Similar substances can be called "Drag Reducing Agents" or (DRA).

Percentage of drag reduction has been found to be able to reach up to 70% [4] in another work drag reduction was reached 60% by using CTAC surfactants [5]. CTAC was utilized in another work to reduce the dray to 72% [6]. Another work accomplished a pressure drop reduction in the range (25-40%) by using 400 ppm dray reducing anionic surfactant type (50s) [7].

Different mechanisms have been suggested for the drag reduction in pipes; Le suggested that the structure of the polar group at on end bonds onto side inner wall of pipeline and non-polar group at the other side smoothes the fluid-solid interface between wall and flowing fluid and hence reducing the fluid turbulence at side interface [8].

Another assumption defined the drag reduction can be caused by suppression of turbulent eddies. Extensional motions dominate in the bursting and growth of these eddies. Kawaguchi [5] assumed anther mechanism for drag reduction, he assumed that the drag reducing surfactant will change the structure of turbulent flow and the mechanism of drag reduction probably also occurred near the wall some mechanism studied the behavior of drag reducing agent in term of degradation by age, and they believed that degradation behavior of surfactant is the key to understand the mechanism of drag reduction [6].

Anther work showed that the rheology properties and the micelle formation in drag reducing surfactant probably the key source to understand the mechanism of drag reduction in presence of surfactant [9].

In this work, carboxyl methylcellulose (CMC) drag reduction agent has been used to find the effect of this material on the pressure drop in pipes by using pressure drop measurement rig.

EXPERIMENTAL WORK

Apparatus

Pressure Drop Measurement Rig

The main part in the apparatus used to accomplish this work is the pressure drop measurement rig which consists of two manometers one for the low flow rates and the other for high flow rates. The first one uses the water to measure the head loss between two points in the test section, while the other uses the mercury to measure the head loss between the same points. The test section consists of stainless steel pipe with 0.5 m length and 0.003 m diameter. That pipe installed vertically in the rig and connected to both manometers by flexible tubes and pressure taping. All of the above mentioned parts are installed on a constant head tank. The outlet end of the test pipe is connected to a valve to control the flow rate of the fluid inside the pipe. A schematic diagram for this rig is shown in figure 1 below.

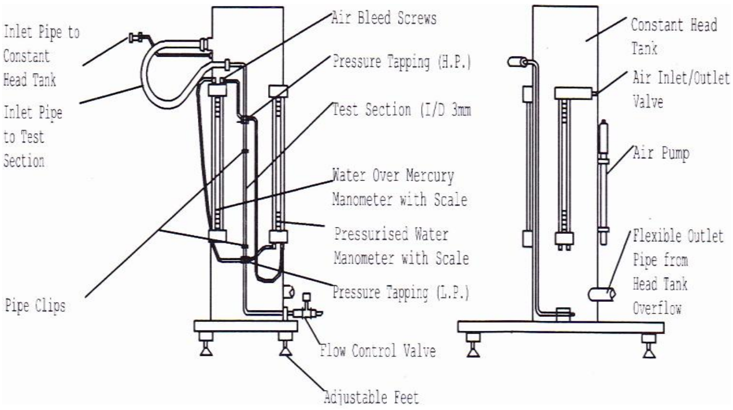

Figure 1: Schematic Diagram of the Pressure Drop Measurement Rig

Hydraulic Bench

Hydraulic bench is a bench that will be used for different purposes; the first and most important use is to use the bench as a fluid supply source to supply the needed fluid with a valve to adjust the flow rate. The second use is to use that bench to measure the flow rate of the fluid output from the bench by using the volumetric tank of the bench, and the last use is using that bench as a base at which the rig can be installed. Hydraulic bench supplied with centrifugal pump having the properties (Head = 21m and max. Flow = 1.35 L/S) and valve to control the flow rate, and level measurement glass column to measure the volume of collected fluid in the volumetric tank.

Used Materials

The main material used in this work is the carboxyl methyl cellulose (CMC solution) which consists of known concentration of CMC surfactant material in water.

Procedure

Preparation of the Solution

The solution that used in this work can be prepared in independent container other than the hydraulic bench. The solution should be prepared with different concentrations by mixing a known amount of the CMC surfactant (the amount can be measured by volume or weight) with known amounts of water. The solution should be prepared in the separated volumetric tank to get accurate volume measurement.

Runs

First of all the air bubbles in all the parts of the rig should be vented to prepare the rig for the work. Two methods should be followed in this work. The first one should be followed for lower flow rates and the second one should be followed for higher flow rates.

Runs for Low Flow Rates

In this case; water manometer will be used to measure the head loss in the pipe; so the flexible tubes that connect the test tube with the mercury manometer should be closed. The input end of the test tube should be connected to the overflow tank output and consider it as a solution supply source. The input flow rate will be constant since the flow rate will be caused by the force exerted by the fluid in the constant head tank. So, the flow rate through the test pipe can be controlled by the valve fixed at the output end of the test tube. At the beginning we will open the output valve totally to obtain the maximum flow rate (maximum flow rate in the low flow rate range), and read the head loss in the test pipe by the water manometer. Then we close the valve little bite to obtain another flow rate and read head loss through the test tube. Continue with this manner until we get zero flow rate with zero head loss.

Runs for High Flow Rates

In this case, mercury manometer will be used to measure the head loss in the test tube, so the flexible tubes that connect the test tube with the water manometer should be blocked. The input end of the test tube should be connected to the valve of the hydraulic bench. The flow rate in this case can be controlled either by the hydraulic bench or by the output valve of the test tube or both. Starting from the maximum possible flow rate at which the manometer column range can indicate the head loss in the test pipe at this flow rate; we will read the head loss at this flow rate. Minimize the flow rate by using one or both of the valves and record the head loss again. Continue at the same behavior until we get minimum possible flow rate.

Taking the Results

In both cases (low and high flow rates), we will record the volumetric flow rate by measuring the time for a known volume of the collected fluid, then divide that volume by the time. Then we will record each flow rate with it’s own head loss.

RESULTS AND DISCUSSIONS

Effect of the Flow Rate

Low Flow Rates

Results for these runs are shown in figure 2 below. We see that when we increase the flow rate form 0.3 cm^3 per second to 2 cm^3 per second; the pressure drop will increase from 3 to 63 cm H2O. These different flow rates have been measured by dividing the collected volume by the time needed to collect this volume. Water manometer has been used to determine the pressure drop in test section at different flow rates.

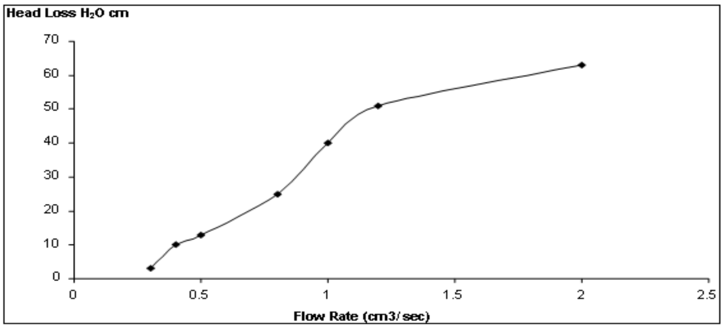

Figure 2: Effect of Flow Rate on Pressure Drop

High Flow Rates

Flow rates have been changed between 2.5 to 5.5 cm^3 per second. Results are tabulated in Figure 2 mercury manometer has been used to measure the pressure drop in the test section. The results of this effect are shown in figure 3 below.

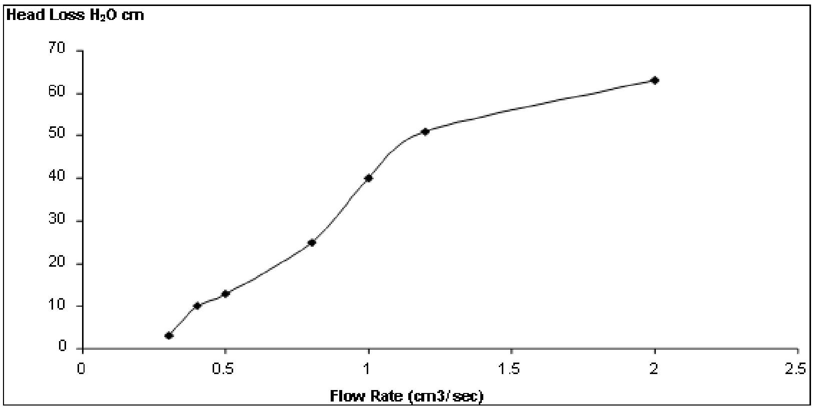

Figure 3: Effect of Flow Rate on Pressure Drop for High Flow Rates

We see that the pressure drop will vary from 5 to 64 cm Hg when we change the flow rate by the mentioned range. Same previous way has been used to measure the flow rates.

Effect of CMC Amount at the Head Loss

Low Flow Rates

Under the same previously mentioned range for low flow rates, three different concentrations of the CMC material have been used to study the effect of these chemical additives on the pressure drop at different flow rates. Figure 4 below shows the effect of 200 ppm, 300 ppm, and 400-ppm concentration of CMC.

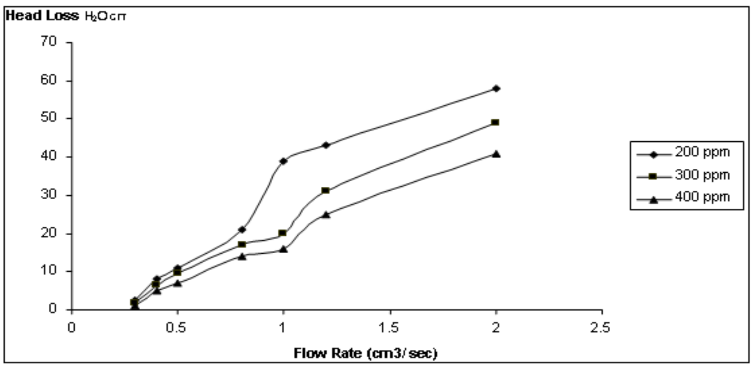

Figure 4: Effect of CMC Concentration on Pressure Drop

From this figure, we see that for the same flow rate the increase in CMC concentration will decrease the pressure drop by a noticeable percent. At small flow rates the effect of CMC concentration will be little different for the three used concentrations, i.e., at 2.5 cm3 per second, the pressure drop will be so close to each other at different concentrations. When we increase the concentration of chemical additives, we see that the effect on pressure drop will be more and clearer. Figure 3 in The reason of this behavior is thought to belong to the reason that the the CMC material will form a sublayer around the flowing fluid which will minimize friction with pipe's walls and hence reducing friction pressure drop component. If more CMC added, the effect may be reverse.

High Flow Rates

Under the same used range of high flow rates, concentration of CMC has been changed three times, 200, 300 and 400 ppm. The effect of these concentrations is shown in figure 5 below.

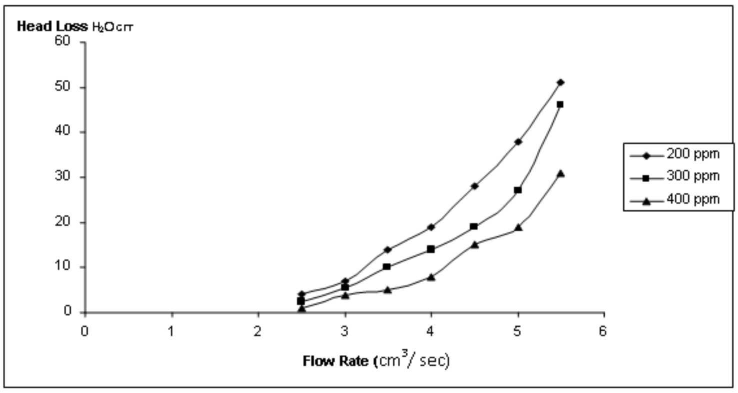

Figure 5: Effect of CMC Concentration on Pressure Drop at High Flow Rates

Similar behavior will be followed when we use high flow rates. At 2.5 cm3 per second, the pressure drops for the three used concentrations will be closely packed. When we increase the flow rate; the difference between the pressure drops for the three used concentrations will be clearer. At 5.5 cm3 per second flow rate; the pressure drop will be 51, 46 and 31 for 200, 300 and 400 ppm CMC concentration respectively. The same previous explanation is thought to be the reason for this behavior.

CONCLUSIONS AND RECOMMENDATIONS

After the experimentations, observations, analysis and discussions on the effect of CMC concentrations on pressure drop in laminar flow, It was found that a noticeable reduction in pressure drop may be obtained by adding different amounts of the CMC material.

Higher different concentrations for the CMC material may be used to study the effect of these chemical additives on the pressure drop at another higher different rate

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